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Abstract title: A Geosynchronous SAR Review

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Abstract:

A geosynchronous synthetic aperture radar (SAR) with an orbit inclination of 50–65° provide daily coverage of basically all of North and South America. Longitudinally, the width of the mapped area would be on the order of ±50° at the Equator, somewhat more at the most northern/southern latitudes. Within the area mapped, very good temporal coverage can be obtained (up to several mappings during the 12 hours per day where the satellite is in the "right" hemisphere). This would be a key capability in relation to disaster management, tectonic mapping and modeling, vegetation mapping, and for operational and semi-operational requirements.

The daily coverage would also provide revolutionary capabilities in the field of radar interferometry, including the capability to study the interferometric signature immediately before and after an earthquake and allowing dense interpretation of transient phenomena thus allowing unprecedented studies of Earth surface dynamics. A geosynchronous SAR for 3-d deformation measurements will provide new insight into the space-time behavior of processes related to earthquakes and volcanic eruptions. Pre-eruptive volcano dynamics could be studied with such a system as well as pre-seismic deformation, one of the most controversial and elusive aspects of earthquakes.

The fine temporal sampling makes a geosynchronous system particularly useful for disaster management of flooding, hurricanes, earthquakes etc. Using a fairly long wavelength (e.g. L-band) changing water boundaries caused by storms or flooding could be monitored in near real time. Interferometric correlation would similarly allow near-real-time mapping of surface changes caused by volcanic eruptions, mud slides, or fires.

A geosynchronous SAR system operating at L-band with co- and cross-polarization backscatter capability would also provide a capability to monitor the biosphere.

This paper will present a system concept review as well as an outline of a possible system implementation including the antenna implementation, system power and weight budgets.

From a technological point of view, the largest challenges involved in developing a geosynchronous SAR capability relate to the very large slant range distance from the radar to the mapped area. This leads to a requirement for large power or alternatively very large antennas. Also, a key requirement for such a system would be the ability to steer the mapping area to the left and right of the satellite, as well as allow control of the elevation and azimuth angles. A ±7° beam-steering capability in both elevation and azimuth would allow targets to be mapped out to 50° angle of incidence on both side of the nadir track. This requires an active antenna capable of 2-dimensional electronic beam scanning. To provide a 10 dB signal-to-noise-ratio out to 50° angle of incidence, which is 4820 km ground range from the nadir point, a 30 m diameter antenna, radiating 15 kW of RF-power with a 20% duty cycle would be required at L-band. The weight of this system is estimated to be 2750 kg and it would require 20 kW of DC-power. Obviously, such a system would be extremely challenging and costly to develop without the use of advanced component technologies and novel system architectures. This paper will address some of the new technologies required for such a mission. Such a system would provide up to a 600 km ground swath in a strip-mapping mode and 4000 km dual sided mapping in a scan-SAR mode. The highest instantaneous horizontal resolution in the strip-mapping mode would 10 m at 5 independent looks whereas the scan-SAR resolution would be on the order of 100 m at up to 60 looks. By staggering the instantaneous bandwidth (~18 MHz) within an 80 MHz band over consecutive days, areas with sufficient interferometric coherence could be mapped with a horizontal one-look resolution of 2 by 2.5 m.

The required processing algorithms would have to be developed. Compared to low-Earth-orbit (LEO) satellites the velocity of the nadir point of a geostationary satellite would vary by more than a factor of two, and the track would deviate significantly from a spherical orbit, in Earth-body-fixed-coordinates. Also, the aperture integration time will be extremely long compared to LEO satellites, which will impose severe requirements on the processing hardware and software. It is noted that the required orbit and antenna pointing control for repeat pass interferometry seems very feasible.

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